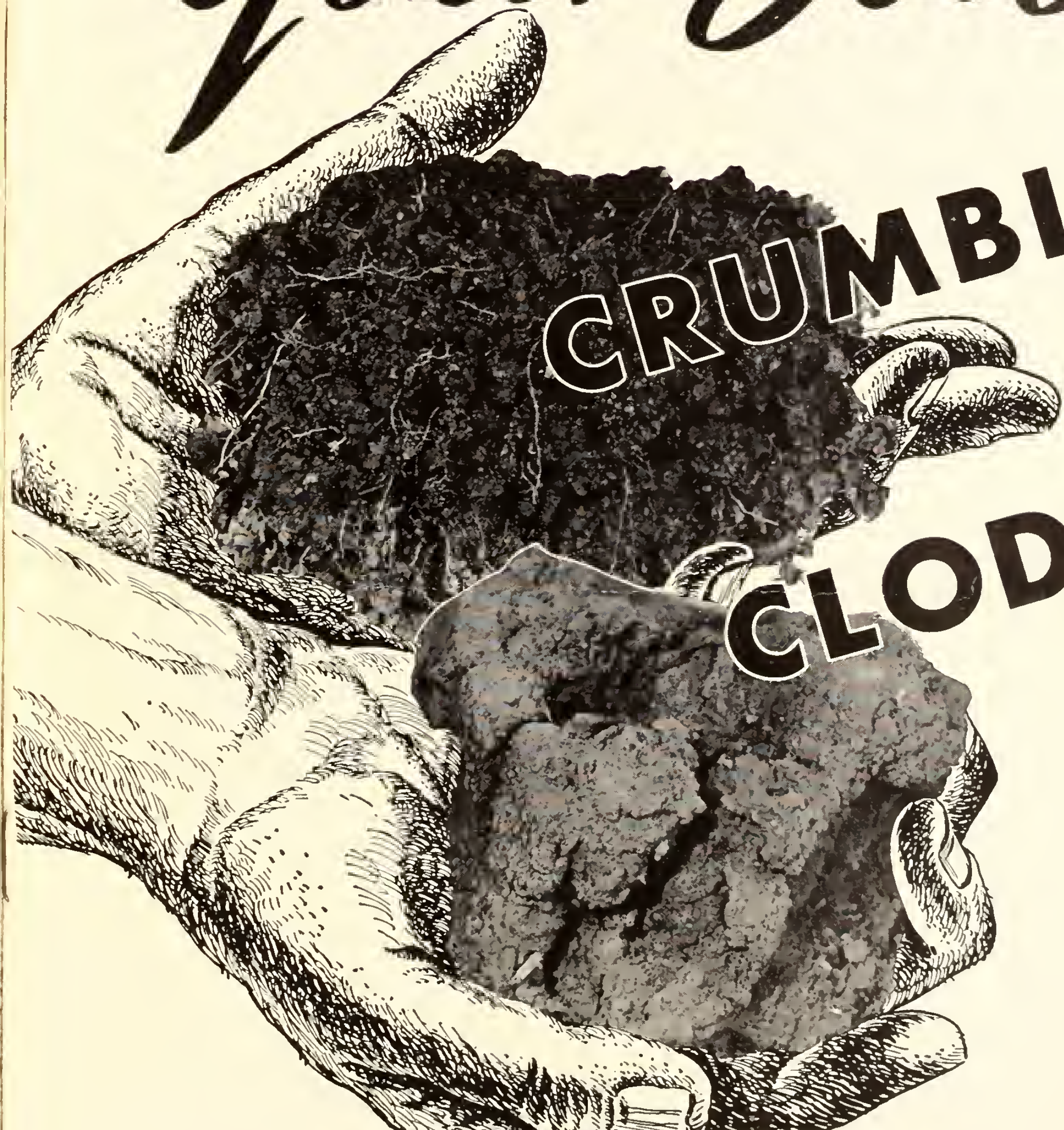
Your Soil...

CRUMBLY or CLODDY ?



UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Conservation Service

Leaflet No. 328

YOUR SOIL—CRUMBLY OR CLODDY?

By A. M. O'Neal and A. A. Klingebiel, *soil scientists. Soil Conservation Service*

Why do crops often suffer from lack of moisture in midsummer, even when rainfall is normal? Why does level land stay wet longer in the spring than it used to? Can anything be done to make soil dry out faster after heavy rains and at the same time store moisture for those hot, dry days in July and August? What can be done to prevent soil and plant food from washing away? There are answers to these questions; a great deal can be done to improve poor soil conditions.

Nearly everyone recognizes the importance of fertilizers and limestone in growing good crops. Soils should be tested to see how much fertilizer and lime the crops will need. When these needs have been filled, then water and air become limiting factors affecting crop growth and yields on many soils. If it were possible to conserve the rain that falls during the summer months the chances of getting a "bumper crop" would be greatly increased.

Plants Need Air and Water

Soils need a certain amount of air if plants are to grow. If soils are saturated with water or have "run together" at the surface, air cannot get in. As a result, poisonous gases may accumulate, less plant food may be available, and plant growth and yields are reduced. Plants, like people, require air, water, and food. Reducing the amounts of any one of these will cut growth and yield of crops.

If you can make more water enter the topsoil, a number of problems will be solved. In the first place, the more water that enters the soil the less there is to run off. Less runoff means less erosion of soil and less loss of plant food by erosion. Secondly, if most of the rain that falls in July and August soaks into the soil, there will be more water available for plant growth during this critical period. Thirdly, since air and water movement in soils are closely related to each other, any condition that causes more water to move into the topsoil will also insure better air circulation.

Tilth Affects Air and Water Movement

The physical condition of the soil that has most to do with air and water movement in the soil is called "soil tilth." A soil in good tilth breaks up easily into crumbs, or granules, about the size of wheat grains or soybeans. These crumbs are porous. They are made up of tiny bits of soil linked together something like popcorn in a popcorn ball. They hold this structure even when soaked. Because of the pores in the crumbs themselves, and because the size of the crumbs keeps them from fitting together as tightly as smaller bits of soil, there is space for air and water. In other words, to have good soil tilth is to have proper air-water relationships in the soil.

Respect for good soil tilth is nothing new. Agriculturists centuries ago said that good soil tilth was essential if the highest yields of crops were to be grown.

Cultivation Has Changed Soil Tilth

Soil tilth has changed a lot during the years that the land has been farmed. You can appreciate this change better if you compare virgin soils with soils found under today's farming conditions (figs. 1-4).

There are few areas of virgin soil left—that is, soil that has never been disturbed. The soils that come nearest to being like the soils the pioneers found lie along old undisturbed fence rows, in road banks that have never been plowed, or in woods that have not been severely grazed or burned.

Dig up some undisturbed soil. Then, dig some soil from a cultivated field adjoining the spot where you

2-5-53

Figure 1.—Virgin soils may still be found along some undisturbed fence rows and in road banks that have never been plowed. Samples dug up from these areas will closely resemble the virgin sod our forefathers broke up.

Figure 2.—A sample of soil dug up from the plow layer of a regularly cultivated field at a spot a few rods from an undisturbed fence row will show how cultivation changes soil tilth.

Figure 3.—This sample of soil was dug from the fence row in figure 1. It is porous, full of grass roots, high in organic matter, very crumbly, easily broken apart. In other words, the soil tilth is excellent—air and water can move through the soil easily.

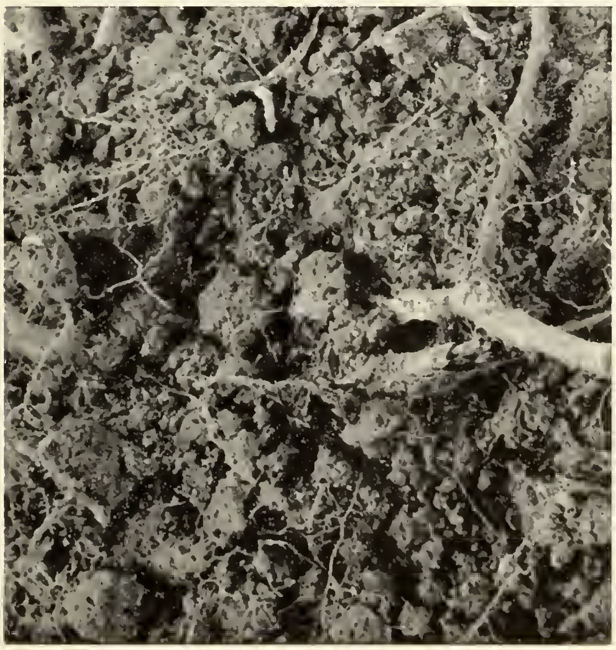


Figure 4.—This sample of soil was dug up from the cultivated field in figure 2. It is harder, heavier, and lighter in color than the fence-row sample. It is cloddy and hard to break. Air and water cannot move through it easily.

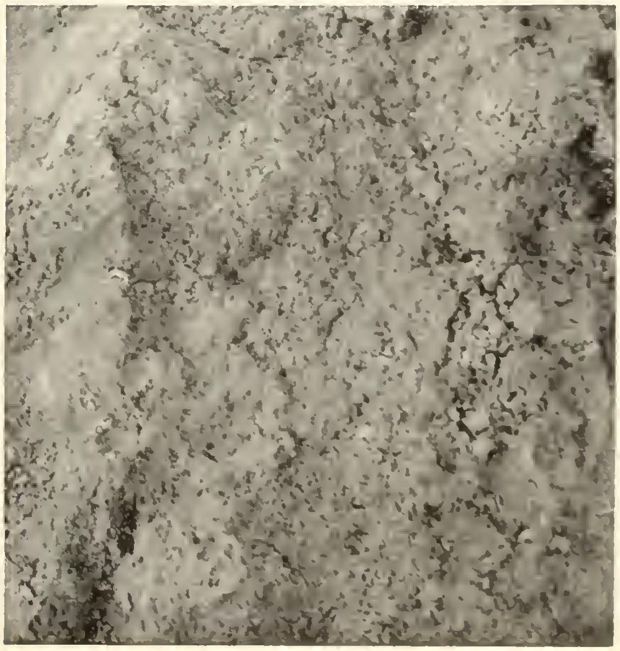


Figure 5.—Samples of soil from an old fence row (left) and from a cultivated field (right) were placed in separate bottles of water, shaken 50 times, and poured out on a piece of paper. Note how the soil with excellent tilth kept its shape, remaining porous and open. The poor-tilth sample ran together and sealed over. This actually happens in the field during heavy rains.

dug up the undisturbed soil. Take this sample from the plow layer of the cultivated field. Be sure to get it from the same kind of soil as that in the fence row or woods, but take it a few rods away.

Compare these two samples of soil for color, organic matter, tilth, weight, and compaction. The soil from the fence row, for example, is porous and full of grass roots. It is high in organic matter (or humus), very crumbly, and easily broken apart. By comparison, the soil taken from the cultivated field is harder, heavier, and lighter in color. It is not uncommon for cultivated soils to have lost from 20 to 50 percent of their original organic matter and to be 10 to 30 percent heavier than they were originally.

After making this comparison, examine soils that have been farmed under good soil management. More will be said about good management later.

Soils Are Different

Some soils just naturally produce more than others. Soils differ as to how fast air and water will pass through them. Before you can know the best use for a particular soil, you must first know its natural limitations. A land-capability map showing the kind of soil, the steepness of slope, and the degree of erosion will help you understand these limitations. A soil scientist working with your local soil conservation district will make this map of your farm.

Land is Now Harder to Farm

What, for example, has happened to Corn Belt soil during the last 100 years of cultivation? When man first broke the prairie he found the soil loose, mellow, and productive. The soil was high in organic matter because the roots, leaves, and stems had died and accumulated for thousands of years. As a result, the topsoil was "like a sponge"—very porous, open, and light in weight. The upper layer let air and water enter just fast enough for the best growth of plants. Thus the soils were able to absorb most of the rain and snow and there was very little erosion on sloping land. Most streams ran clear.

As the land was plowed and cultivated, the living organisms in the soil broke down the organic matter faster than they did under virgin conditions. Most of the crops grown were sold from the land. Crop residues such as stalks, straw, and leaves often were burned and the soil was allowed to remain bare for long periods. As a result, the average cultivated soil in the Corn Belt has lost from 20 to 50 percent of its organic matter.

It is organic matter that gives soil in good tilth a spongelike quality. It helps to keep the soil particles apart and makes the whole soil mass more porous.

Hard Farming Makes Soil Run Together

Working the soil when it is too wet breaks down the porous crumbs in the soil. So does farming the land with heavy equipment. This has resulted in greater compaction. A furrow slice now weighs from 100 to 300 tons more per acre than it once did. This is an increase of 10 to 30 percent. You need more power to plow an acre than you ever needed before. Organic matter and many very fine fibrous grass roots would help form porous crumbs that hold their form and keep the soil from running together when saturated with water.

You can test this for yourself by taking samples of soil from an old fence row and from a regularly cultivated field (fig. 5). Soils with excellent tilth stay porous and take in water while the soils with poor tilth seal over and prevent water from entering.

Raindrops hitting bare soil also break down soil tilth. The raindrops blast the porous crumbs into fine particles (fig. 6). These fine soil particles then "run together" and seal the soil at the surface.

Just how much the tilth of cultivated soils has broken down depends largely on how they have been managed. On many fields, soil tilth has been hurt enough to cause serious problems. For instance, on level land after a heavy rain, water may stand for several days but 12 inches below the surface the soil may be dry.

Surface Crust a Problem

The crust that forms when the soil seals over at the surface is usually one-eighth inch or more thick—an inch is not unusual. In laboratory measurements on samples taken from Illinois (fig. 7), water moved through the crust only one-third to one-fifth as fast as it did through the soil just below the crust. Other studies show that the soil below the plow layer in cultivated fields is 10 to 30 times more permeable to water than the plow layer itself. In tests of many other soils in the Corn Belt results have been similar.

Figure 6.—A raindrop (magnified three times) hitting the surface of a cultivated field. Such blasting soon seals over the surface if organic matter is low. (Photo courtesy Naval Research Laboratory.)

Many people have decided that tile-drained fields which have a surface crust need more tile. But adding more tile will not let water into the soil through a surface crust. The solution is soil management that will improve the tilth of the soil.

One practice that will help prevent the formation of this surface crust is leaving a mulch of crop residues, such as straw or stubble, on the surface. Mulches protect bare soil from the beating of raindrops and prevent it from sealing. Mulches also greatly reduce soil and water losses.

Plow Soles Often Found in Cultivated Fields

Plow soles are developing in some of our soils at the bottom of the plow layer. Like the surface crust, the plow sole restricts movement of water through the soil. You can help prevent a plow sole by making sure the soil is not too wet when worked and by growing grasses and legumes in a crop rotation. Plowing at different depths each time you plow also helps correct the condition.

Good Tilth and High Yields Go Together

There is a close relationship between yields of crops and tilth of the soil. Experiment stations measure tilth by determining the proportions of different sizes of soil clusters and crumbs, which they call soil aggregates. The data in the table on this page were taken from the well-known Morrow plots at Urbana, Ill. In these plots, as the percentage of soil aggregates the size of wheat grains or soybeans increased from 12 to 26, the corn yield increased from 32 to 97 bushels. The organic matter and nitrogen was greater in the well-aggregated soil. These data would, of course, not be exactly the same for all soils, but the general trend will be about the same for most soils except sandy loams, sands, and extremely heavy clay soils.

Once you start cultivating, you cannot keep the original tilth. Experience and studies both have proved this conclusively. Fortunately this is not necessary for high production. In most places it would, however, be desirable for reducing runoff and soil losses.

Figure 7.—Heavy cropping and the beating of raindrops have broken down the original tilth, causing the soil to run together at the surface and form a crust. Air and water move through this crust at a much slower rate than they move through the foot or two of soil below the crust. Crusts a half inch to an inch thick are not uncommon.

Figure 8.—Excellent tilth—soil sample from bluegrass sod in an undisturbed fence row (actual size).

Crop Rotations Influence Soil

The cropping system you use makes a lot of difference in the movement of water in the soil. It also makes a difference in the weight of the soil, and in the amount of water the soil can hold within plow depth. You can check these differences by comparing samples dug from well-managed and poorly managed fields. Soils having poor tilth will be dense and heavy and when dry will look somewhat like a piece of concrete. On the other hand, soils having good tilth

How different cropping systems affect corn yields, tilth, and organic-matter content

Rotation and treatment	Tilth (aggregates larger than 0.25 mm)[1]	Corn yields per acre[2]	Organic matter per acre[1]
	Percent	*Bushels*	*Tons*
Corn-oats	12	32	37
Corn-oats clover	19	62	42
Corn-oats clover with manure, lime, phosphate	26	97	53
Bluegrass sod	67	---	53

[1] Data from Morrow Plots—Agronomy Department, University of Illinois, Urbana, Ill.
[2] 10-year average, 1939-49.

Figure 9.—Poor tilth—soil sample from the plow layer of a field farmed to a corn, corn, corn, soybean rotation for more than 40 years (actual size).

Figure 10.—Good tilth—soil sample from the plow layer of a field farmed to a corn, oats, clover, wheat (clover) rotation for more than 40 years (actual size).

will be loose and lighter in weight and generally will fall apart into crumbs the size of wheat grains.

The table on page 6 gives experiment station data that shows by measurement how different rotations affect soil tilth. The pictures above show how soil tilth affects water movement and the weight of soil. The samples were taken from the Agronomy South Farm at the Illinois Agricultural Experiment Station at Urbana. The soil is Flanagan silt loam.

The soil in excellent tilth (fig. 8) was taken from bluegrass sod in an undisturbed fence row; the soil in good tilth (fig. 10) from the plow layer of a field cropped to a rotation of corn, oats, clover, wheat (clover) rotation for more than 40 years; and the soil in poor tilth (fig. 9) from the plow layer of a field cropped to a corn, corn, corn, soybean rotation for more than 40 years.

When the soil in poor tilth (fig. 9) was first broken from virgin land it looked like the soil in excellent tilth (fig. 8). Today it is dense, compact, and heavy to lift. The top 7 inches of an acre of this soil weighs about 225 tons more now than it did under virgin conditions. This means that more power is required to plow the land. Studies show that only one-fifth inch of water will pass through the plow layer in 1 hour. This is not nearly fast enough to soak up the water that falls during most rainstorms.

Notice the difference between the soil in good tilth (fig. 10) and the one in poor tilth (fig. 9). The soil in good tilth is more crumbly and will soak up water faster. An acre, to plow depth, is about 90 tons lighter in weight. Water will pass through the plow layer at the rate of 3.2 inches per hour. This is 16 times faster than through the soil in poor tilth. The soil in good tilth will also hold about 17 percent more water available for plant growth. This additional water is especially important during dry periods in summer.

In the soil in excellent tilth (fig. 8) it is easy to see the soil granules and the general loose condition. A cubic foot of this soil weighs about 69 pounds as compared with 80 pounds for the soil in good tilth (from the well-managed field) and 87 pounds for the soil in poor tilth (from the severely cropped field). Studies show that water will pass through the top 7 inches of soil in excellent tilth at the rate of 8.4 inches per hour, or 44 times faster than through soil in poor tilth.

Figure 11.—Level land stays wet longer now than it did 25 to 40 years ago. Although water may stand on the surface for several days after a heavy rain, the soil is often dry 12 inches below the surface.

Grass and Legume Mixtures Improve Tilth

Soils that have been severely cropped and are now in poor tilth (fig. 11) can be restored to good tilth by using more grasses and legumes in the rotations. In fact, if we are to have good tilth in our soils and still cultivate them, the land should remain in grasses and legumes for two or more years at a time. With few exceptions, even the very best soils should be in grasses and legumes 1 year out of every 4.

The answered then is rotations containing grass and legumes, along with a high level of fertility to give vigorous growth. Grasses grow mainly in the upper 7 inches of soil. Legumes, such as alfalfa and red clover, have roots that grow deep. Studies show that in the plow layer there will be two to three times more grass roots, in pounds per acre, than legume roots. The fine fibrous grass roots grow all through the plow layer and push the soil particles apart. In so doing they help develop good tilth. The legumes are essential for supplying nitrogen and the deep roots help to open up the subsoil.

Washington, D. C.
Issued August 1952

☆ U. S. GOVERNMENT PRINTING OFFICE: 1952—213106